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THE GAFF-TOPSAIL

(*Felichthys felis*)

A SEA CATFISH THAT CARRIES ITS EGGS IN ITS MOUTH

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FIG. 20. GAFF-TOPSAIL CATFISH

Lateral view of a female, nineteen and one-quarter inches long.
From a drawing from life.

THE GAFF-TOPSAIL

(*Felichthys felis*)

A SEA CATFISH THAT CARRIES ITS EGGS IN ITS MOUTH[1]

By E. W. Gudger,

STATE NORMAL COLLEGE, GREENSBORO, N. C.

Introduction.

At the 1908 meeting of the North Carolina Academy of Science, I gave a short paper on the oral gestation of this fish, but, not being ready to publish, the title only appeared in the proceedings published in *Science* (vol. XXVII, p. 991) and in the *Journal Elisha Mitchell Scientific Society* (vol. XXIV, p. 50).

For the Washington meeting of the American Association for the Advancement of Science in 1911, I prepared, but was unable to give in Section F., a paper bearing practically the same title. However, there was published in *Science* (1912, vol. XXXV, p. 192) an abstract, the data of which forms the closing paragraph of this paper.

Since the more technical data obtained in this research will be presented in a series of papers which will require several years for working up and for publication, it has seemed best to give without further delay an account of the search for incubating males of the Gaff-topsail and of the difficulties met with in obtaining and hatching the eggs, and to present the general data concerning this very interesting phenomenon together with the natural history of the fish.[2]

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[1]Contribution from United States Fisheries Biological Station, Beaufort, N. C. Published by permission of the Commissioner of Fisheries.

[2]I have pleasure in recording here the hearty thanks due my friends among the fishermen of Beaufort, N. C., for testimony as to the carrying of eggs by the fish, for advice as to where and how to take the fish, for specimens, and for a vast deal of arduous manual labor involved in the very extensive seinings carried on for six years. My especial thanks are due to Jack and Southey Mades and Henry Congleton; to W. E., C. F., and J. W. Wheatley; and to Wilbur Whitehurst, Arthur Newkirk, Pete and Billy Garner, Ed Simpson and Walter Longest.

THE SEARCH FOR THE GAFF-TOPSAIL.

Historical Account.

On July 26, 1906, while at Cape Hatteras, N. C., in company with Mr. N. F. Jennett, a pound-net fisherman of Pamlico Sound at that place, I was informed that, on the preceding day while looking over the fishes brought in from his nets, Mr. Jennett had found in his hands some catfish eggs having young on them. By their flat barbels, he had readily identified these little fish as Gaff-topsails in contradistinction to the other sea catfish. The eggs, he thought, were about the size of peas or slightly larger, but whether they came out of the mouth or the vent he could not say.

On returning to the laboratory of the Bureau of Fisheries at Beaufort, N. C. to which I was at that time temporarily attached as investigator engaged in research work in fish embryology, I began to look up the literature with a special reference to the egg-carrying habits of the catfishes and of other fishes.

This search has been kept up ever since, but the literature has been found to be so voluminous that only the data gathered in 1906 will at this time be reviewed. This is given in brief form that it may afford the reader something of an historical setting for the data to be presented herein. However, it is my purpose to publish at some future time a paper now in MS. reviewing the literature of the world on oral gestation in teleostean fishes.

Evermann and Bean, in 1898, in their "Report on the Indian River and its Fishes," say of *Galeichthys milberti,* a near relative of the Gaff-topsail, that "Mr. Stypman of Stuart, Florida, assures us that eggs are never found in this catfish, but that the young are brought forth alive. He says during March the adult females are found filled with well-developed young, each rolled up in a ball, and the various balls connected in a long string. He thinks they hatch out very much like the sawfish. Others give the same information and it sems certain that this species is ovoviviparous."

Evermann and Goldsborough in 1902 in their "Report on Fishes Collected in Mexico and Central America" describe another allied but heretofore unknown form, *Conorynchos nelsoni,*

which carries its young in its mouth. This was a freshwater catfish taken in southeastern Mexico, from the Rio Usumacinto, 125 miles from its mouth. Two fish were collected, both males; of these one, 13.5 inches long, had one egg in its mouth, the other, 16 inches long, had thirty-nine eggs in the oral cavity at the time of its capture. Eight or ten other fish were captured at the same time but none carried eggs. All the eggs of the second fish save four were lost. These four after being in alcohol for two years averaged 10/16 of an inch in diameter.

Jeffries Wyman, while United States Consul at Paramaribo, Surinam, South America, had his attention called in 1857 to certain Siluroid fishes belonging either to the genus *Bagrus*, or one closely allied, which were said to carry their eggs in their mouths. These reports he verified by visits to the markets where these fish were offered for sale for food. He found either eggs or larvae in the mouths of various specimens of *jarra-bakka* and *njinge-njinge*, and was assured by the negro fisherman that *koepra* and *makrede* together with one or two forms had the same habit. The egg-carriers in all the fishes examined by him were males. The eggs of *jarra-bakka* ranged up to three-fourths of an inch in diameter. Of *njinge-njinge*, eight specimens nine inches long were examined. The eggs were in different stages of development, and the number contained in the mouth varied between twenty and thirty.

Günther in 1864 noted this curious habit in specimens of *Arius fissus* from Cayenne in the same region of South America. In fishes six to seven inches long, all males, he found some twenty eggs about the size of a pea, having on them advanced embryos. This habit, he observed, is not uncommon among American Siluroids.

In 1866, Boake described oral gestation in two species of Ceylon catfishes of the genus *Arius*. Their ova were "large" (he seems to have made no measurements of either ova or fish) and immediately after deposition are "taken up either by the fish that has laid them or by another of the same species, and, not swallowed but kept in the mouth until they are hatched and able to take care of themselves, a period of some weeks." Later he ascertained (presumably by dissection) that the egg-carrying fish was the male.

Boake sent to England some specimens of these fishes (two males and one female) which, coming into the hands of William Turner, were described by him in 1867. He confirmed Boake in all respects, and noted that one of his male specimens had ten eggs in its mouth, whereas one of Boake's specimens had thirteen. The other male, like the female, had the oral cavity empty. The "large" ova were about the size of grapes or small cherries and possessed embryos well along in development, measuring 1/2 to 7/10 of an inch in length. Some of Boake's specimens reached Günther also and he in 1866 described and named them. He commented on the habit of the male in carrying the large eggs in the spacious cavity of the mouth, and compared the fish with *Arius fissus* from South America, previously (1864) described by him.

In 1889, Day described the oral gestation of the males of two genera of Indian catfishes, *Arius* and *Osteogeniosus*. The former had eggs averaging .5 to .6 of an inch in diameter, and each carried as many as fifteen to twenty eggs in the mouth. The eggs were in stages of development varying from very early embryos to larvae nearly ready to take care of themselves.

Günther in his "The Study of Fishes" (1880), p. 160, has the following brief reference: "The Siluroid genus *Arius*, the males of which take care of their progeny, produces ova 5-10 mm. in diameter." On the same page, he gives a figure of the ovum of the *Arius boakei* marked "natural size" but measing 14 mm. in diameter. Finally Jordan in his "Guide to the Study of Fishes," (1905), vol. 1, p. 128, writes: "In certain sea catfishes (*Galeichthys, Conorynchos*) the male carries the eggs in his mouth, thus protecting them from attacks of other fishes." Again, in vol. II, p. 179, he says: "In most or all of the sea catfish, the eggs as large as small peas are taken in the mouth of the male and there cared for until hatched."

Having exhausted the literature in the library of the laboratory, I turned to the fishermen of Beaufort and began the taking of testimony, and was surprised to find how many of them had observed in a general way and now gave such unanimous testimony that the eggs are carried in the mouth. One man thought that the eggs came out in strings, another was not sure on this point, but his best recollection was that this was true,

while another believed that they were hung in bunches in the roof of the mouth. All united in declaring that the eggs came out of the mouth and not out of the vent and that in size they were about equal to peas. One man phrased it that "The sea cat spits its young out of its mouth"; and all affirmed that when the fish are struck on the head or thrown into the boats, the eggs would fly out of their mouths. Boake credits the Ceylon fisherman with reporting a similar phenomenon when the egg-carrying *Arius* of that island is captured, the eggs being voided in such numbers that they are gathered from the bottoms of the boats and used for food.

Several other fishermen testified that the eggs are always carried in the mouth, sometimes as many as two handfuls, but not necessarily of the same age, and that they may be found in May and June. One man declared that the eggs were sometimes as large as the yolk of a small hen's egg and that they were "of a pinkish color between white and blood-red."

Data Obtained in 1906.

Structure of Spent Ovaries.

About this time, August 3-6, 1906, there were found in the laboratory pound net considerable numbers of Gaff-topsail catfish, all of which were brought in and examined. The ovaries presented some very interesting structures, but no extended description of them will be gone into here. They were of the ordinary teleostean type, bifurcated in front, but united behind to form the short oviduct which opens out in the urinogenital pore behind the anus. In the ovaries, only the anterior region bore eggs of any size, some of them being as large as small peas. Each of these eggs was enclosed in an investing follicle richly vascularized and was carried on a short pedicel. The middle section had only pedicels from which the eggs had broken away—the follicles having disappeared probably by resorption—together with small, almost microscopic ova in between. The posterior or oviducal part was very curiously plicated or folded longitudinally like the oesophagus of the frog and so abundantly vascularized that while alive it was of a rich beef-steak-red color.

Until August 13, our pound net daily gave us several of these catfish, the females predominating. These fish were all dissected and from the reduced condition of the reproductive organs—the ovaries running 2 to 2½ inches in length—it was clear that the breeding season was long over and that no further work could be done during this summer. Fig. 20, frontispiece, shows one of these spent females, but it might well represent a non-breeding male since there is nothing to distinguish the two sexes at any time other than the breeding season.

The structure of the ovary of *Felichthys*, in conjunction with the reported habits of *Galeichthys*, seemed to indicate that possibly the fish was viviparous, that the eggs might descend into the oviduct and there remain until hatched, nourished by transfusion of oxygen and food materials from the richly vascularized walls of the oviduct by which they might become partly enveloped. On the other hand there were the positive statements of a number of fishermen, men who presumably knew what they were talking about, that the fish incubated the eggs in its mouth. In this state of uncertainty, the question, owing to the lack of material, had to go over until the next summer.

The Search Continued—June-July, 1907.

Structure of Ripe Ovaries.

As soon as it became known that I had reached the Beaufort laboratory in June, 1907, the fishermen began to look out for catfish material for me. On June 4 they brought in a 21-inch female Gaff-topsail catfish which they had split open from snout to anus without finding any eggs. They had even cut into the ovary, following the idea, which had been advanced to them the previous summer that the eggs were possibly carried there, but had found in this only eggs still bound up in their stalked follicles. This ovary was about 4½ inches in length and was crowded with eggs in size from 10 mm. down. Having never before seen such enormous eggs in a teleost and finding ruptured follicles from which eggs had been evaginated not many days before, I came to the conclusion that these eggs must be ripe and that 10 mm. was the normal size for such.

Two days later the same men brought in two Gaff-topsails which had been caught but a few hours before and which were unmutilated. One fish, 16¾ inches long, proved on dissection to be a female with ovaries 3½ inches in length from tip to opening of oviduct. These organs were much distended with eggs 15 mm. in diameter, and occupied 50 to 60 per cent. of the body cavity. The second fish, also a female, was 21 inches long and had the most enormous and remarkable ovaries I had ever seen in any fish. They were 5½ inches long, tightly distended with eggs from 18 to 20 mm. in diameter and occupied from 75 to 85 per cent. of the body cavity. The other organs were very much reduced in size and crowded out of their normal position.

On June 13 there was brought in from our fyke net a 22-inch female with an ovary 5 inches in length, which by its flabby condition showed plainly that the season's eggs had been lately discharged. From all this mass of evidence it was clear that the breeding season of *Felichthys* was at hand, but, being intently occupied with the completion of another research in fish embryology, I was unable at the time to devote myself to this problem.

A week later, my other investigation having ended, I was ready to take up this research; but our fyke net having ceased to yield specimens and the much-expected new pound net having failed to arrive, the fishermen were called on to help.

The Finding of the Fish with Eggs in the Mouth.

On June 22, we went to the Narrows of Newport River some seven miles northwest from the laboratory. Here where the river proper enters the estuary of the same name, there are oyster reefs at the edges of extensive mud flats. As the tides swirl around these reefs, they dig out deep holes and in these holes the catfish congregate at low tide when their mud flat feeding grounds are nearly laid bare. At the uppermost of these reefs, after several unsuccessful hauls elsewhere, a big catch of Gaff-topsails was made. The number of these was unfortunately not noted, though the lengths of thirty-two egg-carriers were recorded. Probably there were from sixty to seventy-five of them in all.

From the mouths of these catfish there were obtained between 200 and 300 eggs. This is a minimum estimate, for, in the confusion and excitement due to such good fortune, no record was kept and afterward at the laboratory other eggs (to be described later), as they died, were put in the same bottles in which this day's catch was preserved. The fact that all these save thirteen were put into killing fluids was due to this same confusion and excitement which was enhanced by the threshing about of sharks and rays and the splashing of a large number of small fishes in the bottom of our boat, together with my being called on every minute to receive a new lot of eggs. Fortunately at the very last of the haul it occurred to me to try to carry in to the laboratory one of the ovigerous males, and to make sure that the thirteen eggs contained in the mouth were not lost, this was loosely sewed up with a bit of small cord. Although the fish was then put into a bucket of water which was renewed from time to time, it died, but the eggs reached the laboratory in good condition and when put into running salt water soon recovered and seemed perfectly normal.

In this connection Wyman may be quoted that in the bagre of Surinam "In many instances the foetuses were still alive through the parent had been dead for many hours." The context not indicating that the parent had been kept in water, it is probable that these larvae had lived because the moisture in the mouth of the parent had kept the egg-shells damp and hence permeable to oxygen.

Omitting small numbers, one catfish gave up eleven eggs, another thirteen, another fifteen, and others sixteen, twenty, twenty-one, twenty-six, the total amounting as stated above, to between 200 and 300 eggs. These eggs showed considerable variation in size, the extremes being from about 17 to 25 mm. in diameter, the average being from 18 to 20 mm. Their large size and great weight together with the extreme fluidity of their yolks, made them very difficult to handle for fear of hurting the embryos lying on the dorsal side. These embryos, as examination later showed, were in different stages, from that wherein the future fish was in the form of an axial rod with forming eye vesicles, to the young in the black-eyed free-tailed stage about 17 mm. long.

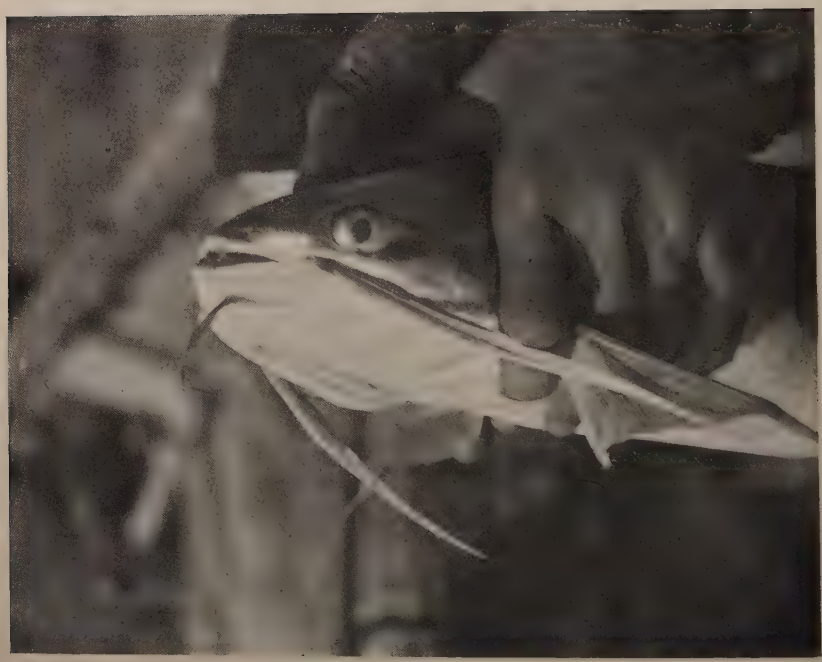

FIG. 21. HEAD OF AN EGG-CARRYING MALE GAFF-TOPSAIL CATFISH

The photograph shows the depressed floor of the mouth and the distended gill-covers

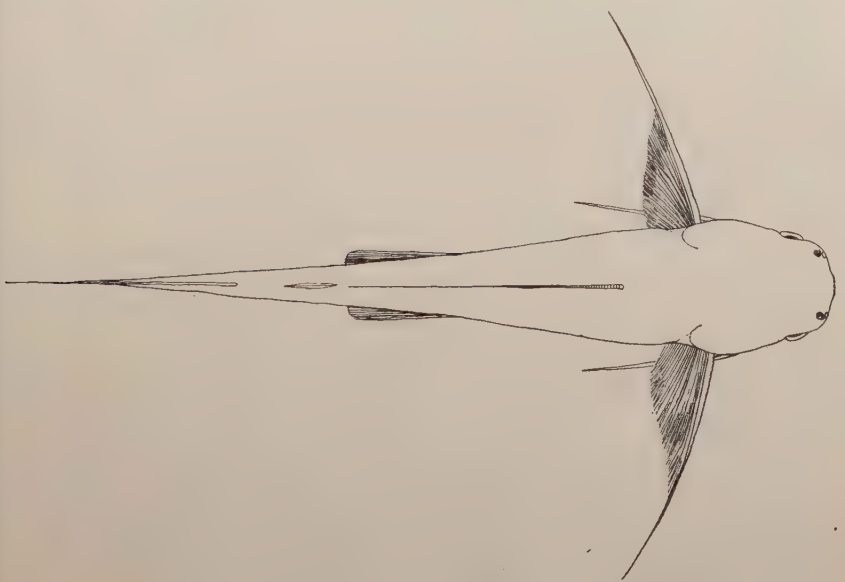

FIG. 22. GAFF-TOPSAIL CATFISH FROM ABOVE
The large head and prominent gill-covers give the fish a marked tadpole appearance. Pen sketch from a specimen 17½ inches long.

The method of procedure in obtaining the eggs was very simple. The fishermen, standing in water and mud up to their waists "fished" in the net, keeping the lead line on the bottom to prevent the escape of any fish. As the net came in the fishermen would grasp the fish just back of the head and in front of the dorsal spine, and keeping their mouths shut to prevent the escape of the eggs, would turn to the boat; then holding the fish with its tail upward, they would allow the eggs to fall or run out into a vessel of water. After being looked over for a minute, or counted in case there was a considerable number of them, they would be transferred to the killing fluid to make room for others.

On this trip only some half dozen egg-carriers were dissected, but in every case the fish was ascertained to be a male. In all the testis was small, stringy, often almost insignificant in size, indicating that the breeding season was past. With the proof by dissection that the male is the carrier of the eggs, the Gaff-topsail catfish falls in line with all other egg-carrying catfishes.

The eggs were loosely held in the mouth, some being pushed into the spaces between the branchial arches, but nowhere was there any evidence of arrangement. It was very noticeable that the mouth cavity, ordinarily so large as to be called enormous, was increased by a distension of the branchial region, but even more noticeably by a marked outpushing or rounding out of the whole hyoid and branchiostegal region. Instead of being flat or insunken as in most fishes and as in all the Gaff-topsails save ovigerous males, this region showed a rounded contour corresponding to the enlargement of the oral cavity, giving the fish a "double chin" appearance.

Figure 21 is a photograph of the head of a living male Gaff-topsail carrying eggs in his mouth. Note the depressed hyoid region and the out-spread gill covers. The mouth is held somewhat closed to prevent the escape of the eggs. Figure 22 is a pen drawing of a living Gaff-topsail, 17½ inches long seen from above. Attention is called to the great size of the head and especially to the width in the region of the gill covers.

Several other collecting trips were made during the summer of 1907 and considerable numbers of eggs were obtained. In one batch of eggs the embryos averaged 20 to 25 mm. in length and fully 3 mm. wide from inside of eyes, while their tails were about half as long as the bodies. Black pigment was noticeable along the dorsal region, the caudal fin rays were visible, and the yolk blood-vascular system was well developed, giving the eggs a beautiful pink or reddish color. (Here recall the fisherman's description.) The heads of the little fish were deeply sunken in the yolk and even the tails occupied little grooves. In this connection an interesting correlation was noted. The heads of the little fish were all twisted, right or left, only one eye being visible, and likewise the tails were twisted right and left. If the right eye was sunk, then the tail was twisted to the right, and vice-versa. This may be seen by careful inspection of figure 23 made from a photograph of the live eggs. However, it seemed to be a matter of indifference to which side the body was bent, for of the 114 eggs on hand, fifty-four had the embryos bent to the right and sixty to the left.

The last trip for 1907 was taken up Newport River on July 18. Again former experiences were repeated, for no catfish

FIG. 23. EGGS WITH LARVAE

Showing the insunken heads, curled tails and prominent yolk circulation. From an instantaneous photograph.

were taken until the mud bottom of the upper oyster reef was hauled. Here was secured one male, 18 inches long and from his mouth were taken 21 actively wriggling larvae, one of which was lost. One of these, of average size, died on its way to the laboratory (probably having been injured in being taken from its father's mouth). After being hardened for 24 hours in 10 per cent. formalin, it measured as follows: Length all over from point of snout to tip of upper lobe of caudal 57 mm.; width, between eyes outside to outside, 11.25 mm.; length of dorsal spine, 14.65 mm. The yolk was 18 mm. in diameter measured in the long axis of the fish, and 16.5 mm. in diameter at right angles to the above—the vertical measurement or depth of the fish was unfortunately not noted. On these fish the black stippling was quite thick on the head and along the dorsal region of the body. It was thickest at the roots of the dorsals and on the body it was arranged in distinct lines following the myomeres. Although the eyes were well along in development, the faint choroid slit could still be seen on the ventral side. The anal papilla showed as a projection in the center of a triangle formed by the pelvic and anal fins. In the nasal region, between the two orifices, a flap-like papilla-shaped organ was noticeable.

Figure 31 shows these little fish in the stage of development referred to. It is from an instantaneous photograph made in direct sunlight. The larvae are as yet unable to lift their heavy yolks. Their mode of progression is by "skating" on their yolk sacs over the smooth bottom of the aquarium.

Further Search, 1908-12.

My summers during the years 1908-1912 were spent in the Fisheries Laboratory at Beaufort in strenuous endeavors to fill out my embryological series of the eggs of the Gaff-topsail and to find out if possible how the eggs are transferred. In this work the few successes were interspersed amid many failures. Had artificial fertilization been possible the first task would have been much lightened, and had the fish been small enough to keep in even large aquaria, the latter might have been possible. But as it was I was never able to get breeding males and females at the same time save once and then artificial fertilization failed; while for the second point there was no tank in the laboratory

large enough to hold these considerable-sized fish. In addition there were other hindering causes which at times defeated all efforts to collect the ovigerous males. A brief recital of these will enable the reader to form an idea of the great difficulties under which research in the habits of fishes is pursued. Later the difficulties met with in the effort to hatch the eggs will be discussed.

Difficulties Due to Heavy Rains.

In 1908 I reached Beaufort on the afternoon of May 28. On the following day 4.02 inches of rain fell. On May 22 it had rained 3 inches, and the total rainfall from May 22 to 29 was 7.79 inches. The total rainfall for the month was 11.07 inches, being 8.05 inches above normal. Again, on July 9-10, 4.48 inches of rain fell in 24 hours, while in a similar period toward the close of the month the precipitation amounted to 5 inches.

The result of all this abnormal downpour was that the water at the head of the estuary of Newport River was so freshened that the catfish, especially males with eggs, were driven out of the deep holes along the mud flats at the Narrows and dispersed in the lower and broader reaches of the estuary where it was exceedingly difficult to find them. Thus it came about that the first lot of eggs was not obtained until June 11, the second lot on June 15, and the third and last on July 7. Consequently, the batch of eggs gotten on the first of these dates was far too old to furnish the early stages so earnestly desired, since, by reason of a grant[1] from the Carnegie Institution of Washington, an artist was at Beaufort to draw figures to illustrate the embryology of the fish.

Again in 1912, the search for the Gaff-topsail was greatly hampered by heavy downpours. On May 22 (the day of my arrival at the laboratory) the rainfall was 1.31 inches, and the precipitation from May 6-22, inclusive, was 7.51 inches. This so freshened the estuary of Newport River that the catfish were driven into the lower harbor, and possibly into the ocean. At least none were taken by any drag-net fishermen visited in Newport River, while the menhaden fishermen reported the taking "outside" of considerable numbers—more than usual.

[1]Figures 20, 22 and 28, reproduced in this paper, were drawn under this grant by Mr. E. A. Morrison. The photographs were all made by the author.

Effects of Cold Weather.

In 1911, more strenuous efforts than ever were made to obtain the early eggs. Having heretofore always reached Beaufort after the beginning of the breeding season, I made two trips this year. It should be noted, however, that the spring of 1911 was a late and cold one, extending well into May. There was a light frost in Beaufort on May 8, while toward the 20th it turned suddenly quite warm. The cold weather greatly delayed the breeding season, while it was greatly accelerated beyond the normal when the warm weather came.

On the first trip the laboratory was reached on May 13. On that day, and on the 15th, trips were made to our favorite fishing grounds. Here great numbers of catfish were taken, mainly large Gaff-topsails with enormous ovaries distended with many large eggs. While their bellies were tremendously swollen, their genital orifices were but little reddened, and no eggs could be obtained though vigorous efforts were made to spawn them.

The males, though smaller than the females, were adult, but from none could milt be obtained. None of the males of the first day's catch had "double chins" indicative of a readiness to receive eggs. However, those of the second day's collecting did have the depressed hyoid region, the throat enlargement, but none carried eggs nor could milt be obtained from any.

On the trip of May 18, not a single *Felichthys* was taken. Evidently it was too early, the ripening of eggs and sperms having been greatly retarded by the cold weather. It was necessary for me now to return to my college duties, but on May 20 Mr. Henry D. Aller, Director of the Laboratory, seined for me, but without getting a single cat.

On May 25, I returned to Beaufort and personally supervised another seining, from which were obtained the youngest lot of eggs but one ever gotten during the whole of this research. These eggs had on them blastoderms with forming embryos, but neither these nor any others ever taken showed the coveted segmentation stages. Further seinings brought in only older eggs, and failure and disappointment were the result of this expenditure of time and money.

Difficulties Due to Inexplicable Causes.

The most disheartening failures of all during this collecting work were those for which no cause could be assigned, for neither rain nor cold weather interfered. At various times during all these six years' work, but especially during the latter half of the season of 1910, trip after trip was made to all our hauling grounds, where in times past boatloads of catfish had been taken, but all were "water hauls," few fish and *no* eggs being taken. At one period some six or eight trips, covering two weeks, did not bring in a single egg. To make these trips, it was necessary to leave the laboratory from 3 a. m. to 7 a. m., in order to reach the seining ground at or before low water.

In the meantime many fishermen were visited. Some of these used seines 1,200 feet long and drifted over a mile of river. They caught few small catfish or none at all, and none carried eggs. A few undersized females had in their stomachs small gray holothurians, which are to be found "outside" only, and hence, it seems to be a possible conclusion that for some unknown reason the catfish had left the brackish river for the saltier ocean.

THE NATURAL HISTORY OF *FELICHTHYS FELIS.*

Description of the Gaff-topsail.

Felichthys felis, (*felis,* cat; *ichthys,* fish), whose portrait forms the frontispiece of this paper, is one of the two kinds of sea catfish found at Beaufort, the other being the much smaller *Galeichthys milberti* previously referred to. The body is elongated, but, as figure 22 shows, very large in the head region, the greatest depth being at the anterior edge of the first dorsal fin. The nostril is double. The eye, which has a vertical pupil, surrounded by a red iris, is placed low on the side of the head and just above the insertion of the maxillary barbel. This latter is flat and very long, reaching almost to the anterior base of the pelvic fin. The pectoral and dorsal spines are continued in long filaments, and these, together with the long, flat maxillary barbels, are such marked features as to make it impossible to confuse the Gaff-topsail with any other catfish found in the salt or

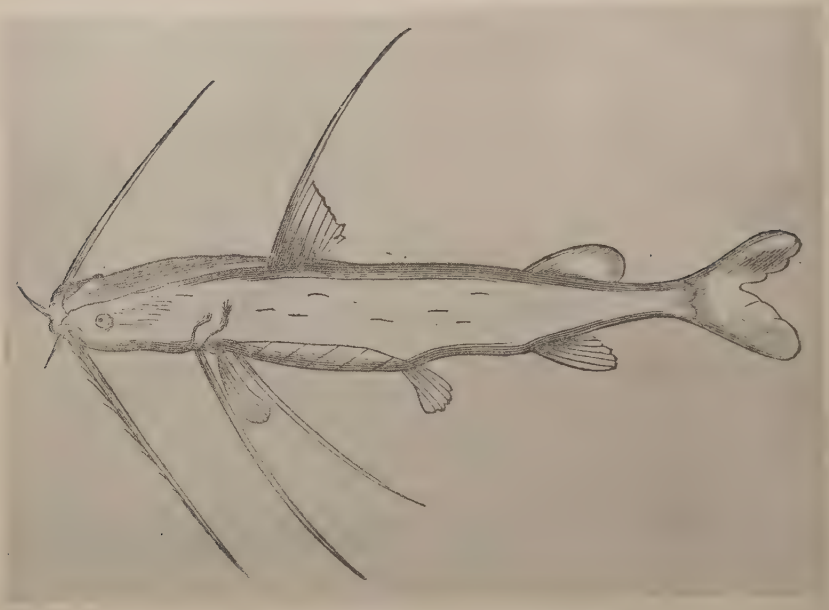

FIG. 24. MARCGRAVE'S GAFF-TOPSAIL
The earliest known figure of this fish (1648).

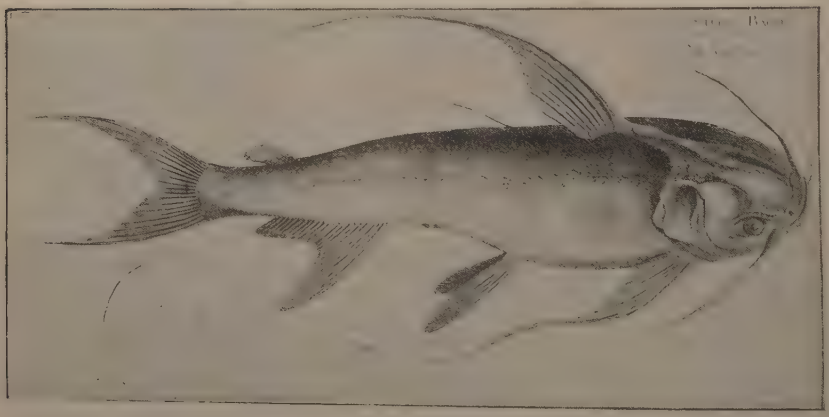

FIG. 25. BLOCH'S FIGURE OF THE GAFF-TOPSAIL (1794)

fresh waters of the United States. The caudal fin is large and deeply forked, the upper lobe being slightly the larger. The color of the fish is a beautiful silvery blue, darker above and lighter below, best seen in lateral view. The fins, especially those on the ventral part of the body, show a reddish tinge as first noted by Mitchill (1815).

History of the Fish.

The discoverer of our fish seems to have been George Marcgrave, in whose Natural History of Brazil (1648) there is figured and described a catfish with flat barbels and long filaments to dorsal and pectorals which is apparently the fish under consideration. Figure 24 is a photographic copy of Marcgrave's figure. This figure, as I have shown elsewhere (Gudger, 1912), was probably painted by Marcgrave himself while in Brazil sometime between 1638 and 1644. It has suffered many things at the hand of the engraver, who seems to have been one De Bray.

His description may be translated: "This Bagre, though of another kind, is in size and shape like the preceding; but it has a beard made of four ray-like barbels, two of which are eight digits long and wide like straps, and two are short ones. To the dorsal fin there is [attached] a similar strap nine digits long, and behind the gills barbels of the same kind. The other [fins] are similar to those of the preceding fish."

Attention is called to the four barbels, the two maxillary ones being long and flat or strap-shaped; and to the strap-shaped (*ligula*) dorsal and pectoral filaments. Another interesting point is to be found in the rays of the dorsal fin. While Marcgrave in 1644 knew nothing of the use of fin rays in distinguishing the genera and species of fishes, he has portrayed his fish with one spinous and seven soft rays in its dorsal fin, the correct number.

Marcgrave's figure and description have been copied by a large number of the old writers. Without going into details there may be named: Piso (1658), Willughby (1686), Ruysch (1718), Johnston (1758), and Bonnaterre (1788). However, that greatest ichthyologist of them all, Marcus Elieser Bloch, in 1794 figured and described a sea catfish from Surinam which

he says is identical with Marcgrave's. Figure 25 here is a photograph of Bloch's fish. He notes that the nostrils are double, that the oblong eyes with black pupils and red irises are near the angle of the mouth. His figure shows four barbels, the two maxillaries being long and flat; and also the long filaments to dorsal and pectoral fins.

Doubt has been expressed as to the correctness of Bloch's identification, but the Eigenmanns in their great monograph on South American catfishes (1890) have identified Bloch's sea catfish with the Gaff-topsail.

Bloch's description gives the fin rays as follows: dorsal, I-8; pectoral, I-12; pelvic, 8; anal, 24. His figure has 26 rays in the anal, but he notes that Gronow counted 23 in the anal of another specimen; it also has I-7 in the dorsal which is correct, though his description says I-8; the figure likewise has 8 rays in the pelvic whereas the true number is 6. However, Bloch in 1794 may be forgiven for a miscount of the fin rays in his figure when Jordan and Evermann (1900) in their figure 52, plate XXIII, have the dorsal fin I-6, and anal 22.

The earliest American describer of the Gaff-topsail was Mitchill in 1815, who took it in the waters of New York. Indeed he definitely gave this fish a place in zoological literature by his splendid description which, however, need not be repeated here. The name *Felichthys felis,* by which the Gaff-topsail is known today, was assigned by Jordan and Evermann in 1900.

Habitat.

This fish is a sub-tropical form ranging as far north as Cape Cod, but is especially common along the South Atlantic and Gulf Coasts where it is abundant in brackish waters, for which it seems to have a predilection. Bloch as early as 1794 noted that, "This fish (the saltwater katfish) is found not only in Brasil but also in the great rivers of North America." By this he probably meant in the estuary mouths of these rivers which are brackish. The Eigenmanns note (1890) that it is found along the Atlantic coast of America from Cape Cod to Rio de Janeiro.

The earliest account given of the occurrence of catfish in North Carolina coastal waters is found in Thomas Ash's "Caro-

lina," published at London in 1682. The reference to seamen indicates that the fish in question was a marine form, and, since (as will be shown later) the Gaff-topsail is the more abundant of the two marine Siluroids on our coast, we may conclude it to be Ash's fish. "—— Cat-fish, whose head and glaring eyes resemble a Cat; it's esteem'd a very good fish, it hath a sharp thorny Bone on its Back, which strikes at such as endeavor to take it; which by seamen is held venemous."

Again, John Lawson says (1714), "Catfish are round, blackish fish with a Great Flat Head, a wide mouth, and no scales. They sometimes resemble Eels in taste. Both this sort and another that frequents the salt water, are very plentiful." The "another sort that frequents salt water" was in all probability the Gaff-topsail. Brickell (1737), whose data seems largely to have been taken from Lawson, does little else than repeat the statements above given.

The first definite record of the occurrence of the Siluroid fish known as the Gaff-topsail in North Carolina waters was made by Yarrow in 1877. Since his day the fish has been well known and often recorded.

At Beaufort *Felichthys* is taken everywhere in the "rivers," which are really brackish estuaries. My best catches have been made at the very head of Newport estuary, within one mile of the limit of tide water, where at dead low water the density was 1.007.

It is very abundant on both coasts of Florida; in the Indian River so much so as to be a great nuisance to the fishermen. It is also abundant in all the sound-like lagoons and the estuarine river mouths opening into the Gulf of Mexico.

H. M. Smith (1907) says that the smaller relative of the Gaff-topsail, *Galeichthys* (weasel-fish) *milberti*, is the most abundant of the sea catfish at Beaufort, but I have not found it so in my many years of seining there. The Gaff-topsail is found in large schools, and I have often taken 100 or more at a haul, while my fishermen on one occasion caught a wagon-load, estimated at over 500, ranging from 20 to 25 inches in length. On the other hand I have never taken more than a half dozen at a time of the small-mouthed catfish. It seems to be a shy and possibly a rather solitary fish.

Swimming Habits.

The Gaff-topsail is a bottom liver, and generally not a very rapid swimmer. The strong tail and deeply forked caudal fin might lead one to think to the contrary, but, if the fish is viewed from above (Fig. 22), it is readily seen that the enormous head parts would render it impracticable if not impossible for the fish to get up much speed.

Although a bottom swimmer, nevertheless as the net comes in, the Gaff-topsail has the interesting habit of swimming near the surface of the water with the dorsal fin, or at any rate the filament, projecting above the water. This habit of carrying the dorsal fin and filament in an elevated position gives it its name, Gaff-topsail. DeKay as early as 1842 made note of this peculiar swimming habit. In Newport River at dead low water, when the fish, driven off the mud flats as the water lowers, collect in deep holes, this same habit may be noticed.

Furthermore, for two weeks in the summer of 1910 I kept a 12-inch *Felichthys* in a 4 by 6 foot wooden tank in the laboratory at Beaufort, and during this time it persisted in swimming at the surface of the water with its dorsal filament carried high out of water. At the same time two *Galeichthys* in the same tank as persistently swam at the bottom 6-8 inches below. Gaff-topsail larvae also show a marked tendency to swim at or near the surface of the water of their aquaria. Even more marked is their habit of "hanging" motionless at the surface, much as a frog does.

Behavior when Caught in a Net.

When caught in a seine, the Gaff-topsail has the very annoying habit of rolling itself up and very effectively entangling its dorsal and pectoral spines in the meshes. So firmly imbedded does it sometimes become that it is necessary to break its spines or to cut the net to get rid of it.

It is also a great annoyance to the fishermen in another way. All fish give off a slimy mucus which is very destructive to nets, causing them to rot rapidly, but of all fish known to me the Gaff-topsail, when caught, gives off not only the most slime, but

the most tenacious. Only repeated washings and rubbings will take it off the hands, and it is almost impossible to get it off the nets. Fishing for and handling this catfish is a very nasty matter.

Defensive Habits.

So far as I have been able to ascertain the Gaff-topsail has no offensive habits. Twelve and fifteen-inch specimens kept in tanks with various other and smaller fishes showed no tendency to molest these latter. It is true that *Felichthys* is sometimes found with fish in its stomach, but it is not impossible that these were dead or at any rate disabled ones which were not able to escape the relatively slow moving catfish. Certain it is, as will be shown in the next section, that the food of this species is mainly crustacean.

However, weapons of defense are present in the shape of dorsal and pectoral spines and are capably used. If the fish is caught and held by the tail it will swing violently and convulsively to the right and left almost through an arc of 180°, endeavoring to strike with its pectoral spines. If picked up incautiously it will almost surely wound one. The only safe way to grasp it is across the back of the head in front of the dorsal spine, the thumb on one side and the fingers on the other behind the pectoral fins. Held firmly thus (see Fig. 21), it is almost incapable of inflicting a wound. Such wounds, while quite painful, are not especially dangerous, though bacteria carried in with the slime may set up an inflammation and the slime itself may possibly be toxic.

These points were covered by Thomas Ash, two and one-third centuries ago. Writing in 1682, he says of a marine catfish on the coast of North Carolina (for reasons given before, presumably the Gaff-topsail): ". . . . it hath a sharp thorny Bone on its Back, which strikes at such as endeavor to take it; which by Seamen is held venemous; yet, I saw one of our Seamen, the back of whose Hand was pierced with it, yet no poysonous Symptoms of Inflammation or Rancor appeared on the Wound, which quickly healed, that I concluded it was either false, or that of this Fish there were more kinds than one."

Food and Feeding.

The Gaff-topsail is an omnivorous feeder, almost anything being meat that comes to its mouth, whether fish or crab or worm. It seems to affect mud flats and after them submerged sand flats as feeding grounds. The water in the Beaufort region, where the sea cat-fish is found, is too muddy for any observations to be made on the feeding habits, but if one may judge of these by analogy after observing the habits of the young (4 to 6 inches long) in a large aquarium, it probably feeds by swimming a few inches above the bottom with its long barbels, tactile organs, just touching the surface of the mud. Whenever these touch anything edible, there is a quick turn, a sudden opening of the cavernous mouth and it is gone. I have often experimented with the young, and have found their barbels exceedingly sensitive to bits of oyster dropped into the aquarium. I have seen the little fish thus arrested, stop in full flight and even turn a somersault in its eagerness to get at the oyster. The fish, of course, would readily perceive moving objects and if these were edible, would snap them up. The feeding described above is more that of a scavenger.

The food of the adult is—anything edible. I have on dissection found the stomach filled with fish, worms, crabs. The latter, however, is its staple food, and I have taken from the stomach blue crabs so large that it was difficult to see how they could have been taken into the mouth and down the oesophagus. Autopsy has revealed the presence of ascidians, and, during one summer, certain small gray holothurians as noted above (page 138). H. M. Smith, (1907), notes similar feeding habits and food for the smaller ocean catfish, *Galeichthys milberti,* at Beaufort.

Before leaving this subject it may be noticed that in Florida this and the other marine catfish are accused of feeding on human feces. I have had a very detailed account of this from a man who is absolutely reliable, and his account has been corroborated by a scientific friend who has personally seen the fish thus engaged.

Parasites.

As might be expected from its omnivorous feeding habits, the Gaff-topsail harbors a considerable number of worm parasites. However, as the greater number of my autopsies have been performed at the fishing ground with other points in view and while greatly pressed for time, my notes merely record the finding of worms in the stomach. Further, however, it is interesting to note that another investigator, working at Beaufort on internal protozoan parasites, has found in the intestine of our fish considerable numbers of a large potato-shaped ameba having remarkably clear protoplasm and a rapid rolling motion. This and other results have not yet been published.

Use as Food.

The value of the Gaff-topsail as a food fish is, irrespective of other points, considerably diminished by the large size of its head and by the bony cuirass extending back to the origin of the first dorsal. Nevertheless, it has been, and is used as food. Bloch, (1794), says that it is eaten, but that its flesh is not especially palatable. Ash, (1682), remarks of the marine catfish that: ". . . . it's estem'd a very good Fish." The older American ichthyologists thought highly of it as a food fish. Thus Mitchill, (1815), says, "It is an exquisite fish for eating." While De Kay, (1842), writes: "Its flesh has been represented to me by those who have eaten it as having an exquisite flavor." But Jordan, (1884), while remarking that its flesh is palatable, says that it rarely is saved for food, for the most part being thrown away.

Various authors, Jordan and Gilbert (1883), Henshall (1891, 1895), Evermann (1899), Gregg (1902), and others, writing of this fish in our southern waters, say that by reason of the abundance of other and far better fish it is rarely eaten, save by negroes. I never knew the fish to be eaten at Beaufort, nor was there any demand for it for export save in one season. There was a considerable shortage of fish in 1908 and a New Bern fish dealer, who had a "buy boat" anchored in Newport River, bought Gaff-topsails along with other common (non-choice) fish to sell

to the negroes of that town. I have eaten its flesh, in order to be able to report on it, and have found it not unpalatable, but not particularly appetizing. Perhaps, however, it was not well prepared.

Sounds Made by the Fish.

Felichthys felis makes two distinct sounds, one a croaking and the other a rasping sound. The first is the more common and is produced by the swim bladder. If the fish be grasped back of the pectorals, distinct pulsations may be felt with every croak. These are very apparent in a fresh and vigorous fish, especially if it shows signs of anger. Larvae also croak and by holding them in the fingers it will be noted that, as in the adults, pulsations may be felt in the body wall.

The rasping sound made by the Gaff-topsail was first thought to be due to the fish rubbing its superior and inferior pharyngeals together. However, it was soon noticed that the grating or rasping sound was accompanied by a spamodic jerk of the pectoral spines, and that if these were held immovable no rasping sound could be perceived although the croaking continued, the gritting noise beginning again when the spines were released. So it seems that these sounds are made by the spines as they rotate in their sockets.

On one occasion, after some resistance on her part, I took a large active female cat from the water and laid her down in the dip net on a small pile of oyster shells, whereupon she made a spitting noise for all the world like an angry tabby cat. I am not sure how it was done, but it was possibly a combination of the two sounds previously described, and the pile of oyster shells may have acted as a resonator aiding in combining the two sounds. This was the only occasion on which this peculiar sound was noticed.

Size of Breeding Females.

It will be of interest briefly to consider the size of breeding fish, and first of the females. In fish generally these run larger than the males, and in our catfish this is especially true, due largely to the enormous ovaries filled with huge eggs ranging up to 25 mm. in diameter.

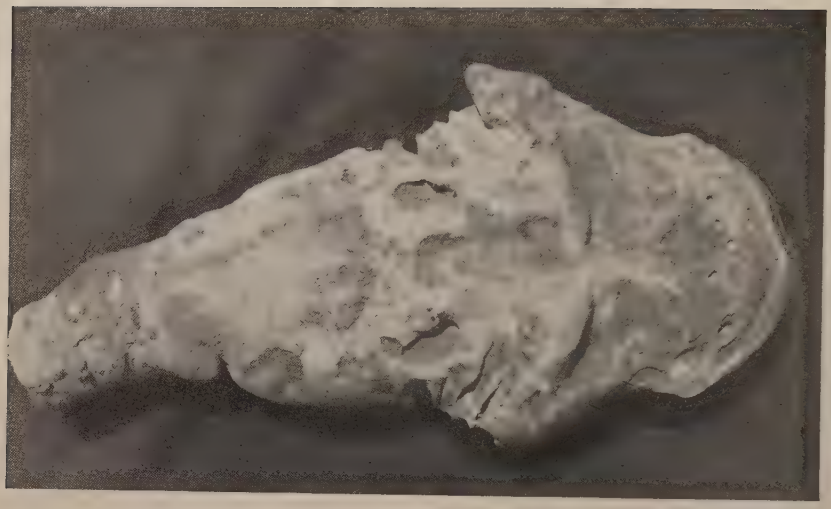

FIG. 26. CEMENT CAST OF THE MOUTH OF THE MALE FISH CARRYING 55 EGGS
Dorsal view.

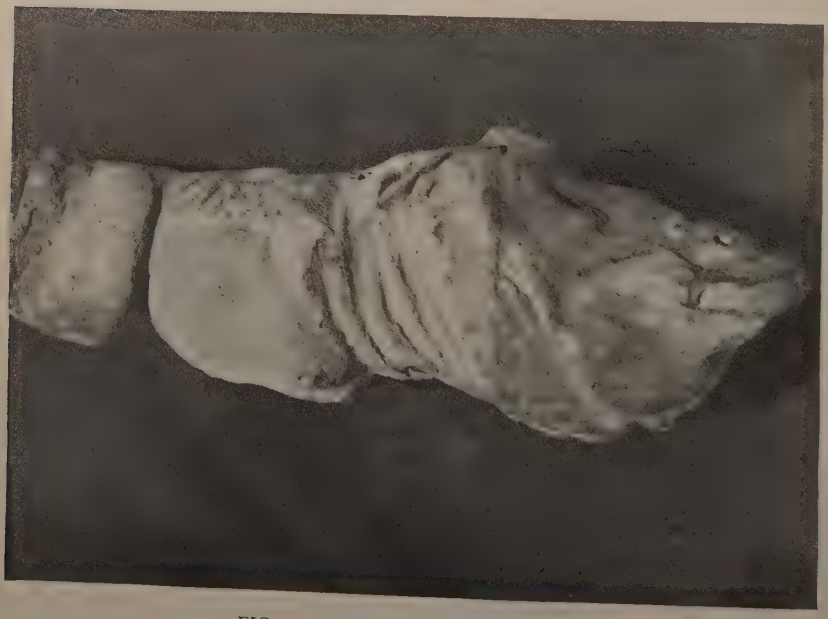

FIG. 27. CEMENT CAST OF MOUTH
Lateral view of Fig. 26.

The fish taken on May 13 and 15, 1911, are quite typical of breeding females. These had not spawned their eggs and hence had enormous bellies. The largest, taken May 15, measured: 19½ inches, 1; 20 inches, 2; 22½ inches (15 inches in girth), 2; 23 inches, 1; 23½ inches (14 inches in girth), 1; 24½ inches, 1; 25 inches, 1. This last was the most enormous catfish I ever have seen. She measured 19 inches in circumference just back of the dorsal fin, the filament only of which (whence the name Gaff-topsail as noted above) was 3¾ inches long. She had, however, not reached her maximum size for her eggs were not ripe—they could not be spawned.

Size of the Incubating Males.

This can best be set forth by giving the sizes of 32 egg-carriers measured on the initial trip taken in this research, June 22, 1907. It will be noted that their sizes run very uniform, but that they are markedly smaller than the females. On this day there were measured: 1, 15¾ inches over all; 4, 17½ inches; 9, 18 inches; 3, 18¼; 7, 18½; 2, 18¾; 1, 19; 1, 19¾; 1, 20; 1, 20½; 2, 21: 32 in all. Of these 32, 23 range from 17½ to 18½ inches; and generally speaking later observations confirm these figures as being the average.

How the Eggs Are Carried.

These breeding males, as previously noted, carry the eggs loosely in the mouth, the gill-covers being widened outwardly and the hyoid distended downward to make the "double chin" previously referred to. In this way the cavity of the mouth is enlarged and its capacity increased. As may be seen from figure 22, which is a pen and ink sketch of a 17½ inch breeding male, the Gaff-topsail, like most siluroid fishes, is largely head, and the head is mainly mouth. Figure 21 shows the mouth distended in the hyoid region to accommodate the eggs.

Size of Mouth Cavity.

A number of casts were made of the mouths of fish carrying large numbers of eggs, but of them only the largest will be considered here. This was of a 22-inch male burdened with fifty-five eggs, the largest number ever obtained from any Gaff-topsail in the course of this work. This fish was carried to the laboratory, seven miles away, that the capacity of its enormous "Keim-höhle" might be made. However, there was but a small quantity of plaster of Paris in the laboratory and *none* in Beaufort. In this predicament, Director Aller came to the rescue with the suggestion that cement be used, there being a barrel at hand. So a tolerably thick grout was made and the mouth filled with it, a towel being wrapped around the gills to prevent the escape of the cement before it had hardened. The head was then cut off, put out in a cedar thicket, where covered with a box it was left until the ants had eaten off the flesh. Later it was cleaned, shellacked, and photographed. Figures 26 and 27 are dorsal and lateral, views of this huge cast. The volume of this cast, up to the insinking in the oesophageal region, is 580 cc.

Size and Structure of the Skull.

In intimate connection with the size of the mouth is the matter of the magnitude of the skull. Reference to figures 20 and 22 shows that the head makes up a large part of the body, about one-quarter of the length and possibly an equal part of the bulk. The buccal cavity, as has been shown in the preceding section, is enormous. In order that the reader may get a clearer idea of what gives it this great size, two views of the skull are given. Figure 28 is Mr. Morrison's drawing of the dorsal surface, while figure 29 is a photograph of the ventral surface of the same skull. The buccal cavity extends the whole length of the under surface of the skull, the hinder part, the beginning of the oesophagus, being formed under the coalesced vertebrae.

Since such would be apart from the purpose of this paper, no attempt will here be made to work out the osteology of this very interesting skull. However, attention may be called to its armor-clad dorsal surface. This will explain why so much

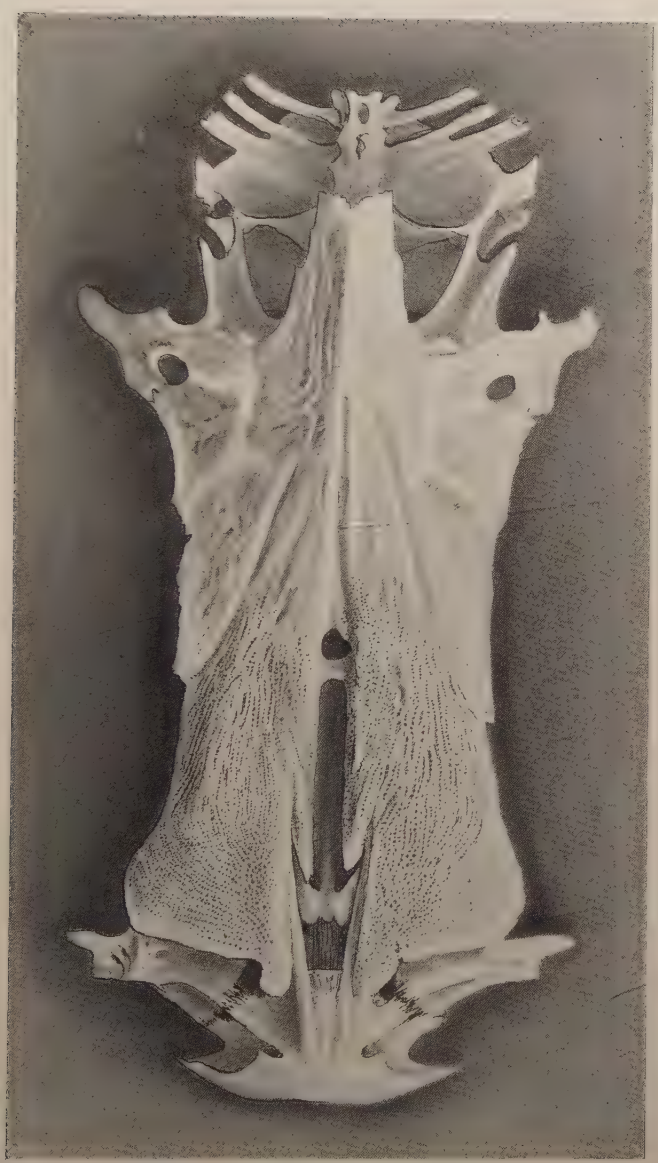

FIG. 28. SKULL OF THE GAFF-TOPSAIL
Dorsal view showing the fontanelle.

clubbing on the head is required to subdue an active catfish. There is, however, one easy method of quickly and comparatively easily killing a catfish. This is by inserting a knife blade through the slit in the anterior median line in the bony armor. Through this the brain is easily reached. This open space in the roof of the brain is called a fontanelle. In the higher bony fishes it is closed, and its presence here is an evidence of the lowly position of the catfish in the class Pisces. It is an inheritance from its shark ancestor, which had a very marked fontanelle in the corresponding region of its skull.

The only person, who, so far as has been found, seems ever to have noticed this structure in the skull of the catfish and consequently this method of killing it, was John Luccock. Luccock made a journey in 1808 to Rio de Janeiro and the River Plate, and twelve years later published a very interesting account of his travels which contains many valuable natural history notes. In speaking of the Bagre caught in the La Plata off Buenos Aires, he says: "It lives long out of water and is with difficulty killed by blows. I observed in the plate of the skull, between the eyes, a small aperture, covered with a thin whitish membrane, and imagined that through this, it might be killed by touching the brain. We accordingly introduced a filament taken from one of the bass cables, which produced an immediate paralysis and the fish died without further suffering."

Turning to the ventral surface of the skull of *Felichthys* we find some equally interesting structures. In the posterior region are the large round paired bullae containing the ear stones. Ventral and posterior to these we have a curious bony formation very like a crucifix, the two little semi-circular bones behind (above) it looking somewhat like a halo. I have the indefinite recollection of having somewhere read of the feeling of semi-veneration paid to the catfish skull showing these structures by the superstitious inhabitants of the Guianas and the neighboring islands but I have been able to lay hands on but one reference.

The Beebes in their charming book, "Our Search for a Wilderness", (1910) say that, while their vessel was anchored in one of the mouths of the Orinoco: "At the bottom, our hooks would

be taken by great fierce-whiskered cats, bedecked with long streamers, which gave no end of trouble before they were quieted. They were pale yellow, and the head and back were encased in bone; Maestro the cook called them the Crucifix fish, and later showed us why. On the under surface of the bony armor is a large cross with a halo about it just above the arms. The crew never caught one of these fish without making the sign of the cross in their right palm".

The Beebes give a photographic reproduction of "the crucifix in the catfish", but their figure seems to have been made from a skull that had suffered considerable erosion. It does not have the sharpness and clearness of detail found in figure 29.

Size of Eggs and Number Carried.

The ripe eggs vary in size as is to be expected, running from 15-25 mm., but the average diameter is 19-20 mm.. The smallest number of eggs found in the mouth of any gestating male was two. Two fish were found, 13 and 15½ inches long over all, each with two eggs. Once, it is true, a large male was found carrying only one egg, but from the great size of his buccal cavity there is good reason to believe that other eggs had been thrown out in the process of capture. This I have known the Gaff-topsail to do. Large numbers of eggs are by no means unusual; a dozen fish have been taken with eggs in the thirty's; forty-five eggs have been taken twice; fifty were obtained from a 22-inch male; and greatest of all fifty-five from another fish of the same size.

Attempts to Hatch the Eggs Artificially and the Difficulties Met With.

Early in the course of this investigation it was seen that it would be necessary to carry these eggs by artificial means to the point of hatching and beyond, if an embryological series was to be obtained. However, it seemed doubtful if eggs accustomed to such a highly specialized brooding chamber could possibly be carried on to hatching in open jars of running sea-water.

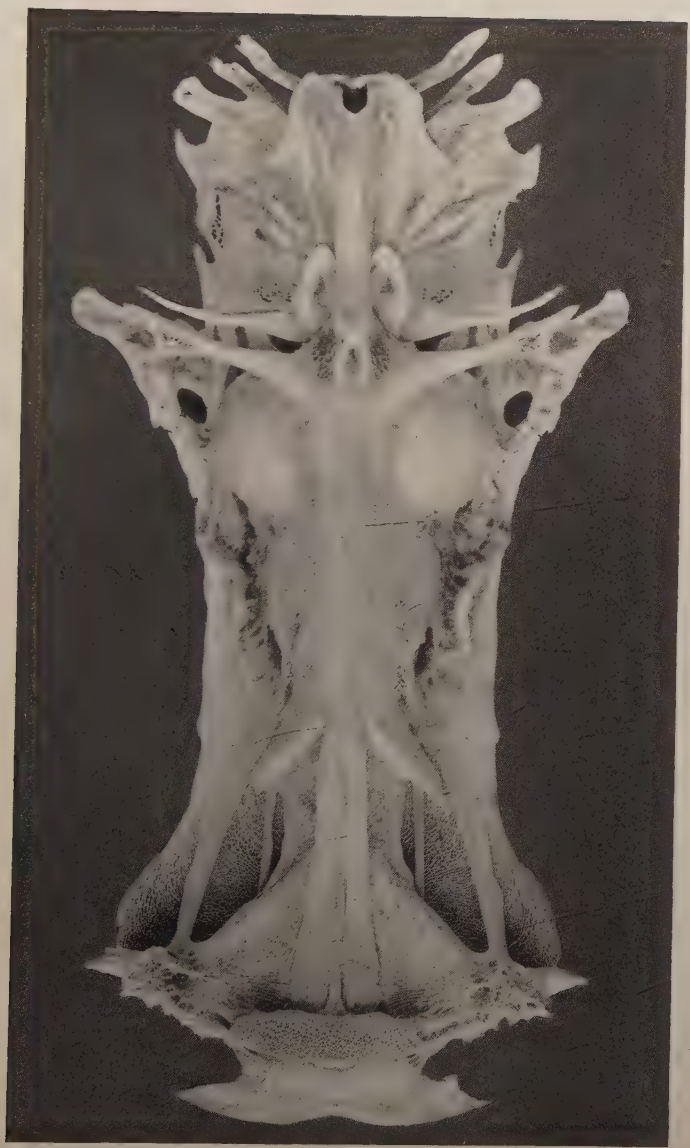

FIG. 29. VENTRAL SURFACE OF SKULL

Showing the "Crucifix in the Catfish."
Photograph of same skull as Fig. 28

Unfortunately it was never found possible to bring incubating males to the laboratory, for the fish either died or at best became sick and spat out their eggs. The eggs however could readily be brought in in pails of water renewed at intervals.

But for all this great difficulty was experienced in keeping these eggs alive. At first they were kept in shallow glass aquaria under running salt water, but the fine sediment from the water so thickly covered their shells that the supply of oxygen was to no inconsiderable degree cut off. That this was not the only cause of their "going bad" was, however, afterwards ascertained.

To remedy this, some of the eggs were put in filtered sea-water with *Ulva* and placed near a window but not in direct sunlight. Though some died, others did fairly well for a while. The greater number, however, were put in baskets of a coarse-meshed galvanized wire netting and hung in aquaria 9 inches deep under running salt-water—the idea of course being that the greater part of the sediment would fall through to the bottom. These baskets were hung with copper wire covered with thread and erroneously supposed to be paraffined. Possibly this combination made a weak electrolytic apparatus. At any rate, on the day following their suspension thirty-nine dead eggs were taken from the baskets. The baskets were then suspended by zinc-coated wires, but the mesh being rather large, the heavy eggs settled down in it in such a way as to cause congestion in the yolk circulation and finally death.

After the death of all the eggs, as noted in the preceding paragraph, another trip was made and another lot of eggs in fine condition was brought in. Each had an embryo on the top nearly ready to burst the shell. Each little fish rested in a groove in the yolk, the head lying flat with both eyes above the groove. The tail of each was bent, the caudal fin covering one eye and reaching to the edge of the other. Here again see figure 23.

The eggs continuing to die daily, in seeking to remove all possible causes, it was thought that the density or saltness of the water might be too great. This at the laboratory averaged 1.021, while at the Narrows of Newport River, where the fish were caught, it was at the surface 1.007. To obviate this possible cause a number of eggs were put into filtered sea-water

diluted with filtered rain-water to a density of 1.016 and were placed under running water of the same kind carried over by a siphon. These eggs all died, possibly because the flow of the siphon was insufficient to aerate the water in which they were placed. Presently but one egg remained. The larva on this had burst its tough shell on the dorsal side, and through the slit had thrust its head and the anterior part of the body. With its projecting eyes, black with a golden ring, and its head parts faintly stippled in black, it presented a striking and beautiful appearance. Fig. 30, A and B, from photographs made on this day, give some idea of the dorsal and ventral surfaces of this egg; only colored drawings could do it justice. Probably as a result of the handling incidental to the photographing of this egg, is was found dead the next morning.

All other methods having failed to bring about the hatching of these eggs, it was determined to try the hatching jar devised by former Commissioner of Fisheries MacDonald and named after him. In this apparatus water is admitted to the bowl-shaped bottom of a tall glass jar, whence it rises up through the eggs and escapes by means of a pipe at the top. The purpose is to keep the eggs continually in motion and to carry off all sediment, bacteria, and mold spores by the escape pipe at the top. With the catfish eggs it was hoped that the current of water would be sufficiently strong to keep the eggs agitated, to lift them up enough to prevent the congestion of the ventral yolk-sac circulation consequent upon the considerable weight of yolk plus embryo. However, the outcome was only partially successful, for even in the hatching jars the mortality was very great.

On July 7, 1908, a trip to the Narrows was made in the hope that hatching eggs might be gotten. In this we were successful for two cats were taken. One, 17¼ inches long, carried thirty-six eggs. The little cat on one of these eggs had burst its prison and had thrust its head out of the rent in its shell as shown in figure 30 and the others were about ready to do so. The other male carried in his mouth six larvae 53-55 mm. long over all, sitting on yolk sacks so heavy that they could not yet lift them. Here again see figure 31. This would seem to fix the first week in July as the approximate hatching time.

A B

FIG. 30—A & B. A LITTLE GAFF-TOPSAIL THAT HAS JUST BURST THE SHELL

A—Dorsal view. B—Ventral view.

From an instantaneous photograph.

FIG. 31. LARVAE OF THE GAFF-TOPSAIL CATFISH

From an instantaneous photograph of the little catfish skating on their yolk-sacks at the bottom of an aquarium.

Great difficulty was experienced in hatching these eggs. Some died with congested yolk circulations as described above for the previous year, others gradually grew pale and finally died without any definite cause being found. And now there was developed a new trouble which threatened to carry off all the remainder at hatching time. Their shells seemed to grow rotten so that the fishlets by vigorous twistings could burst them at one place or another. When this took place in what may be called the anterior region, so that the head could be thrust forth, all was well. For this see figure 30. But when as more commonly happened, the shell burst elsewhere and the compressed yolk pushed out the investing wall with its plexus of blood vessels forming a hernia, death shortly ensued from strangulation of the circulation unless the trouble was relieved at once. At this stage in the history of the little cats, life was conserved only by constant vigilance. I kept watch by day and until 11 o'clock at night and the night fireman thereafter; and, whenever a "herniated" egg was discovered, the shell was torn partly or completely off the egg and the hernia pressed back into place with the smooth handle of a scalpel. This was a rather rest-disturbing matter since I was frequently awakened three or four times in one night. But the operation was for the most part successful since some 75 per cent. of the young so treated recovered. The majority of deaths in these "hulled" eggs resulted from the congestion of the ventral yolk circulation brought about by the weight of the fish and yolk or by the continued wriggling of the fishlets. Those from which the shells had been removed suffered especially, since their yolks flattened down greatly, while those whose shells were merely torn open, but not removed, suffered far less since their yolks were partially supported. All were put on beds of cotton wool at the bottoms of aquaria under jets of sea-water.

During the season of 1909 in endeavoring to hatch the eggs, the experience of the past seasons was repeated. The eggs went forward very well till they neared the time when they might be expected to hatch, then they died by fives and tens and twenties. An interesting phenomenon may here be noted which may offer a possible explanation for some of these deaths. On July 1 there was noticed inside the shell of an egg a small mass of greenish-yellow matter looking much like the fecal matter given

off by a young baby and noted as such at the time. Further an embryo at the time of hatching or a few minutes thereafter had hanging from its vent a string of fecal matter. A third egg on the same day exhibited a similar state of affairs. All this leads one to question whether it may not be that some of these eggs which die just at the time of hatching are poisoned by fecal stuff given off by the embryos and confined within the egg shell.

The embryos from the paternal mouth, which were just ready to hatch, had far less difficulty in ridding themselves of their shells than the ones brought up in MacDonald hatching jars. And while it is probable that there is some mortality among the eggs incubated in the mouth of the father, there is no doubt that it is nothing like so great as that among eggs hatched artificially.

Just as the percentage of fish hatched in the paternal mouth is greater than that of those brought up in a hatching jar, so is it probable that the young incubated therein mature earlier than in the jars. This seems to be confirmed by this fact. On July 20, my fishermen, men whom I know well and in whom I have great confidence, brought in a little cat about four inches long taken from the mouth of a 20-inch male. This little fish was grown in the sense that its body walls had completely coalesced over the yolk. The men reported that they saw several little ones in their net. These they tried to catch, but they escaped through the meshes of the seine, the large fish, however, retained one in his mouth. This young one gave much trouble by jumping out of the bucket of water into the bottom of the boat, and finally escaped by jumping overboard as it was being handed to me at the wharf.

In contradistinction to the early hatching noted above in the mouth of the father, of the larvae in captivity, taken on July 7, 1908, the older ones did not close over their yolk sacs until August 5-8, while the corresponding dates for the younger captives was August 15-17. Making all allowance for difference in time of beginning incubation, the two or three weeks' interval separ-

ating the periods of yolk disappearance in the two sets of larvae is too long to be accounted for satisfactorily save on the ground that the young in the mouth of the paterfamilias develop more rapidly. This must be due to the fact that they feed while therein.

How the Embryological Series Was Obtained.

For six years (1907-1912) the search for the fish and its eggs went on, and with few successes and many defeats the series of eggs was pushed both backwards and forwards. By fitting in one egg here and another there and a third elsewhere, the series is now complete from invagination to the free swimming young in which the walls of the belly have closed over the diminished yolk sac and have coalesced into a raphe on the median line. The inability to obtain the segmentation stages is a great disappointment, for they only are lacking for the complete embryology, but, since the most strenuous efforts continued for six years have failed to obtain them, I have come to the reluctant conclusion that chance in the case of this fish will play more part in the collecting of eggs and embryos than any amount of hard and long continued effort.

Conclusion.

How the eggs are extruded, fertilized, and transferred is not known, but when these processes are effected the male incubates the eggs in his mouth not only until they are hatched by the bursting of the shell, but until the yolk has been absorbed and the young are able to take care of themselves. The largest number taken from the mouth of one male was fifty-five. A cement cast of his mouth had a volume of 580 cc. The volume of an average sized egg is 3.75 cc., of the fifty-five eggs 206.3, add 25 per cent for interstices; total space occupied by the fifty-five eggs equals 258 cc. This fish was 22 inches long and of average size. The eggs average 19-20 mm. in diameter, and the young fish at the end of the period of incubation are 85-100 mm. long. The length of this period can not be stated definitely, since it has been found to be impossible artificially to carry the

eggs and embryos to the stage of the free-swimming young. However, it is probably about seventy days. During all this time the paternal nurse does not seem to feed. The large eggs would, if spawned on sandy or shelly bottoms, be quickly destroyed by crabs or by other fish; if laid on a mud bottom (where the breeding fish are caught) their considerable weight would cause them to sink into and be smothered by the mud. This habit is common in estuarine catfish in all tropical and warm temperate regions. These data are based on six summers' work at the Beaufort laboratory of the United States Bureau of Fisheries, in which time scores of male fish carrying eggs and larvae have been captured and autopsied.

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